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TITLE: Flow of complex biological macromolecules in microfluidic devices

AUTHOR: Shrewsbury, Polly Jean [Ph.D.]; Liepmann, Dorian [adviser]

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AB Microfluidic systems harbor the potential for increased efficiency in biochemical analyses. The realization of this potential hinges upon identifying the interdependency between microfluidics, macromolecular conformation, and system geometry. Accordingly, this work focuses on understanding the transport, orientation, and deformation of biological macromolecules within microfluidic devices.

Epifluorescence microscopy was used to characterize the behavior of macromolecules flowing through silicon-fabricated microfluidic devices. Of specific interest was the effect of flow on the conformation of λ-DNA macromolecules. Rheological characterization of λ-DNA solutions, with regard to fluid relaxation times, aided in this endeavor. Three studies in two devices were conducted.

The first study investigated the conformation of dilute solutions of λ- DNA (c = 0.001c*) under flow in a straight channel microfluidic device. The flow contained both regions of high elongation and shear. The molecules exhibited tremendous heterogeneity in conformation. Histograms of the distribution of conformations, measured along the channel centerline as a function of axial position, revealed dramatic stretching resulting from the converging flow. The molecules eventually returned to equilibrium coil size, but far downstream of the channel entry. High shear rates near the channel wall also resulted in dramatic stretching of the molecules, and may result in chain scission of the macromolecules.

In the second study, the concentration of λ- DNA in solution was increased (c = 0.1c*). All other variables were held constant. Although both the elongational and shear flows stretched the macromolecules, the deformation in the more concentrated solution was less than that in dilute solution. In contrast to dilute solution, at the same or slightly higher Deborah number, no evidence of molecular degradation was observed as the macromolecules traveled through the channel.

The third study probed the effect of channel geometry on dilute solutions of λ- DNA macromolecules (c = 0.001c*). Our analysis shows that the complex flow patterns generated by the sudden expansions, sudden contractions, and straight channels comprising a planar micro check valve can influence macromolecular structure and stability. Therefore, through these studies, we demonstrate that molecular structure and concentration, flow parameters, and device geometry all bear significant consequences when designing microfluidic systems. The interplay between these variables influences molecular stability and the accuracy of sample analysis.

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L1 167 E3 OR E4
L2 0 DUO REM L`
L3 107 DUP REM L1 (60 DUPLICATES REMOVED)
L4 7 L3 AND FLUID AND DNA